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# **“The Quality of Undergraduate Crown and Bridge Impressions: The Report of a 3-Cycle Audit”**

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## **ABSTRACT**

**Introduction:** The importance of an accurate impression of a prepared tooth is essential for the construction of an indirect restoration. Several UK studies have highlighted deficiencies in the quality of impressions. Clinical audit is an accepted method of quality assessment, assuring appropriate treatment outcomes.

**Aim:** To audit the quality of crown and bridge impressions taken by undergraduates at Bristol Dental School.

**Audit Process:** One hundred impressions taken by dental undergraduates for the provision of indirect restorations were audited in 2014, one hundred impressions in 2016 and a further 100 impressions in 2018. Impressions were inspected under magnification and assessed for a variety of factors related to quality.

**Results:** The proportion of 'satisfactory' working impressions rose considerably from 2014 (42%) to 2018 (72%). In 2014, 42% of impressions had faults at the impression margin, and this fell to just 2% by 2018. By 2018, 100% of impressions were taken in an appropriately sized tray, and almost all (98%) were adequately disinfected.

**Conclusion:** This paper reinforces the benefit of clinical audit. The 2018 audit found that 85% of working impressions were of an acceptable standard which compares very favourably with previously published studies.

**Keywords:** Audit Undergraduate Crown Bridge Impressions

## INTRODUCTION

Crowns and bridges are provided to patients to satisfy requirements of both function and aesthetics. They are constructed using an 'indirect technique' allowing the fabrication of the restoration away from the chairside, by substituting a gypsum cast poured from a master impression of the prepared tooth. If the restoration is to fit the preparation precisely, this cast must replicate the prepared tooth/teeth and associated areas of soft tissue.<sup>1</sup> The British Society of Restorative Dentistry (BSRD) defines the purpose of a master impression as a way in which "to obtain an accurate, dimensionally stable, fully supported impression of the prepared teeth and associated soft tissues".<sup>2</sup> Only with a good quality impression can a close-fitting cast be made. The quality of crown and bridgework is thus a reflection of the skills of both the clinician and dental technician, and the effective communication between them. Previous research has made it evident that communication between the dentist and laboratory could be improved to provide optimum patient services.<sup>3</sup> This finding is supported by another study that found almost one-half (47%) of impressions sent to dental laboratories throughout the United Kingdom and Ireland provided poor or no written instructions.<sup>4</sup>

Two further studies have looked at variations in bridge construction in commercial dental laboratories and both found many faults in the construction of bridges.<sup>5,6</sup> However, both studies concluded that the responsibility of the standard of restoration laid not with the laboratories and their practice, but with the clinicians. Technicians can only work with the impressions and information provided to them. A subsequent study investigated the quality of impressions for anterior crowns at a commercial dental laboratory that were received from dentists in general practice.<sup>7</sup> This study concluded that the majority of impressions did not satisfy accepted criteria and had significant faults that would lead to restorations with defective margins and reduced longevity. In addition, some impressions were found to be contaminated with blood and other debris. A larger study on 290 cases from 4 commercial dental laboratories was also carried out.<sup>8</sup> The results of this study mirrored the previous study in terms of quality and contamination and drew the attention of the profession to the deficiencies of the current practice.<sup>8</sup>

The responsibility of ensuring an impression is clean and disinfected before it is sent to the laboratory lies with the dentist. The impression should be rinsed under running water to remove saliva, blood and debris until it is visibly clean and then disinfected according to the

manufacturer's instruction. However, studies have found that the disinfection of impressions generally fell far short of recommended guidelines and many were obviously contaminated with blood, plaque, food or other debris, placing laboratory workers at serious risk.<sup>4,8</sup>

An ideal working impression should also be made from a rigid impression tray so that the flanges of the tray are not displaced by the impression material.<sup>9</sup> If flexible trays are used, the tray will recoil on removal and may distort the impression material, resulting in an inaccurate cast. However, a later study found that in general dental practice most impressions were taken with flexible, disposable plastic trays.<sup>10</sup>

A good quality impression is a prerequisite to the construction of well-fitting crowns and bridges. It is important that preparation margins be clearly seen on the impression if the resulting restoration is to have a satisfactory marginal fit. It is the dentist's responsibility to critically evaluate the impressions recorded before dispatching them to the laboratory for processing. However, previous studies reported impression defects at the finish line in over a third of cases.<sup>7,8</sup> Indistinct margins will mean that the technician will have to compensate by guessing where they lie, and thus the restoration may be compromised from the start. Although intra-oral scanning devices are now available, and their use is becoming more routine, a variety of traditional impression materials and techniques are still widely used.<sup>11</sup>

A more recent study found that 44.2% of impressions had faults at the margins that rendered the impression unsatisfactory.<sup>12</sup> This study also found that NHS impressions were twice as likely to be unsatisfactory than impressions taken in private practices. A subsequent study found 129 out of 200 impressions unacceptable.<sup>13</sup> This study concluded that these poor results may have been due to clinician factors, patient factors or could be associated with properties of the material used. Dentists themselves may have below adequate knowledge and not enough clinical experience of the necessary techniques. Additionally, dentists may not be manipulating the impression adequately and agreed that financial issues could be a constraint leading to unacceptable impressions being sent to the laboratory.

It is important that dental undergraduates are fulfilling the clinical Intended Learning Outcomes set out by the General Dental Council in the document 'Preparing for Practice'.<sup>14</sup> Of particular relevance is the Learning Outcome which states that a dentist must "manage restorative procedures that preserve tooth structure, replace missing or defective tooth structure, maintain function, are aesthetic and long lasting, and promote soft and hard tissue health". Undergraduates should also have a sufficient understanding of clinical and laboratory

processes so that they can evaluate their own clinical work, the quality of their impressions, and the work received from dental technicians.<sup>15</sup> However, undergraduates have been found to show poor understanding of the dental technicians' techniques and procedures and only 26% of technicians believed that dental students were taught to communicate with dental laboratories effectively.<sup>16</sup> This may be attributed to a reduction in the amount of 'hands-on' dental technology training provided for dental undergraduates.<sup>16</sup> Furthermore, a previous study of UK undergraduate teaching of crown and bridgework concluded that there was great variation between the schools under investigation in terms of the impression materials used, the use of stock trays and the routine use of disinfection.<sup>17</sup> Concerns with impression quality is not confined to the UK. A recent study at the Virginia Commonwealth University School of Dentistry found 27% of unsatisfactory undergraduate impressions were submitted by qualified general practitioner supervisors.<sup>18</sup>

The inability for a technician to construct a restoration from an inadequate impression or failure of a constructed restoration to fit will have both clinical and financial implications, and it is therefore in the interest of all stakeholders to ensure that impressions made are of the highest quality.

## **CLINICAL AUDIT**

Clinical audit is an accepted method of confirming clinical standards and highlighting any areas in which improvements are needed so that the highlighted areas can be addressed.<sup>19</sup> Clinical audit can be described as a cycle. Within this cycle there are stages that follow a systematic process of establishing best practice, measuring care against criteria, taking action to improve care, and monitoring (by re-auditing) to sustain improvement.<sup>19</sup> The stages of a clinical audit are:

- Identifying the audit subject
- Agreeing standards of best practice
- Collecting data
- Comparing data against standards
- Feeding back results
- Discussing possible changes
- Implementing changes

## **AIMS AND OBJECTIVES**

**Aim:** To audit the quality of crown and bridge impressions produced by undergraduates at Bristol Dental School.

### **Objectives:**

- To inspect the impressions received at the laboratory and record the frequency of any faults, voids or drags and the degree of detail recorded, especially the marginal accuracy of prepared teeth.
- To evaluate the suitability of impression material for the individual situation based on their handling characteristics and properties, and the quality of the fixation of the impression material to the tray.
- To assess the choice of impression tray used, its rigidity and the extension of the tray to support the impression material.
- To detect evidence of decontamination of impressions according to published guidelines on infection control.
- To determine the overall level of quality of impressions and make recommendations where any short fallings are identified.

## **AUDIT PROCESS**

Approval from the University Hospitals Bristol Audit Committee was obtained for the each of the three cycles of this audit.

For the purpose of the audits, the standards and targets set are shown in Table 1. In each of the three audit cycles, impressions were allocated a case number; a unique code assigned by the laboratory, which anonymised the patient but enabled the authors to monitor the impressions. Only the academic year of the student who made the impression was recorded. Data was collected before work had been carried out on impressions. The impressions for the first 100 cases received that required crowns, bridges, inlays or onlays were examined in each audit. There were no exclusion criteria.

Magnification loupes were used to inspect each impression and data was recorded on a new data collection form (Table 2) for each case. The working impression, the opposing arch impression and any bite registration was inspected by either a single (or pair) of Year-4 dental undergraduates as part of their Dental Elective projects. Evidence of decontamination and the presence of a laboratory prescription form was also recorded. Where there was any doubt regarding the degree of accuracy of the working impression, a senior laboratory technician was consulted to provide guidance.

Examples of features associated with each working impression that would lead to the overall grading are shown in Table 3, and examples of such impressions are seen in Figures 1a-c.

**2014 Audit:** One assessor (ZP) visited the conservation production laboratory at Bristol Dental Hospital, twice weekly, between the months of May and September 2014. One hundred impressions were examined, and a summary of the results is shown in Table 4. All impressions were correctly disinfected with no unwashed debris visible. All impressions taken used correct tray sizes. Every case included a laboratory prescription form. All impressions used a plastic stock tray and recorded the full arch in a 'one stage' technique. Dual viscosity addition-cured impression material (putty/wash) was the material used for all cases, whilst polyether and monophase addition-cured silicones were not used. All impressions employed the 'one-stage impression technique'.

The type of faults recorded in working impressions is shown in Figure 2. Faults related to the impression margin were highest (42%). The overall quality of impressions found only 42% to be satisfactory and 31% being satisfactory (Figure 3).

Following this initial audit, an action plan was devised by the Audit Committee:

- Dissemination of results to all Hospital and University staff and dental undergraduates via e-mail, along with details of the action plan
- Updating supervising clinicians as to the desirable features of a satisfactory impression
- Use of magnification and greater illumination when assessing the quality of impressions on the undergraduate clinics by supervising clinicians.
- Direct communication between supervising clinicians and the dental laboratory for cases where the quality of the impression is unclear



- Re-evaluation of the current undergraduate teaching curriculum with regards impression taking for fixed extra-coronal restorations and the assessment of impressions.
- Re-audit after 6 months

The Audit Lead was responsible for implementing the Action Plan.

**2016 Re-audit:** A pair of assessors (SM & AP) both visited the conservation production laboratory at Bristol Dental Hospital, twice weekly, between the months of March and July 2016. One hundred impressions were examined, and a summary of the results is shown in Table 4. All impressions were correctly disinfected with no unwashed debris visible. Eighty-two percent of impressions taken used correct tray sizes and there was evidence of inadequate tray fixation for 2% of impressions. Every case included a laboratory prescription form. All impressions used a plastic stock tray and recorded the full arch in a 'one stage' technique. Dual viscosity addition-cured impression material (putty/wash) was the material used for all cases, whilst polyether and monophasic addition-cured silicones were not used. All impressions employed the 'one-stage impression technique'.

The type of faults recorded in working impressions is shown in Figure 2. The overall quality of impressions had fallen with only 36% being deemed satisfactory (Figure 3).

Following this first re-audit, an action plan devised by the Audit Committee:

- Dissemination of results to all Hospital and University staff and dental undergraduates via e-mail, along with details of the action plan
- Encourage staff and students to directly enquire with a laboratory technician if there is doubt as to the quality of an impression before it is sent to be processed
- Ensure that sufficient illuminated magnifiers are available on clinic
- Make it mandatory for staff to use illuminated magnifiers (or loupes) when inspecting impressions
- Update laboratory forms such that staff will need to sign to confirm that impressions have been inspected under magnification
- Re-audit after 6 months

The Audit Lead was responsible for implementing the Action Plan.

**2018 Re-audit:** A pair of assessors (LH & KA) both visited the conservation production laboratory at Bristol Dental Hospital, twice weekly, between the months of January and April 2018. One hundred impressions were examined, and a summary of the results is shown in Table 4. There was evidence of adequate disinfection for 98% of impressions in 2018, where two of the impressions still had evidence of debris. All impressions used adequately sized trays, although one tray was insufficiently loaded affecting the quality of the impression. Every case included a laboratory prescription form. All impressions used a plastic stock tray and recorded the full arch in a 'one stage' technique. Dual viscosity addition-cured impression material (putty/wash) was the material used for all cases, whilst polyether and monophase addition-cured silicones were not used. All impressions employed the 'one-stage impression technique'. All but one case had included opposing arch impressions and occlusal records, where necessary.

The type of faults recorded in working impressions is shown in Figure 2. Only 2% of impressions has faults related to the margins. The overall quality of impressions had risen with 72% being satisfactory, with only 15% being unsatisfactory (Figure 3).

Following this second re-audit, an action plan was devised by the Audit Committee:

- Dissemination of results to all Hospital and University staff and dental undergraduates via e-mail, along with details of the action plan
- Remind supervisors of the essential features of a satisfactory impression.
- Remind undergraduates of the need for good communication between operator and nurse to prevent faults due to poor timing.
- Remind supervisors that all impressions need to be assessed under magnification.
- Re-audit after one year.

Again, the Audit Lead was responsible for implementing the Action Plan.

## **DISCUSSION**

The results of the original 2014 audit were disappointing. Whilst there was a 100% attainment of standards related to disinfection and the correct use of impression trays, only

42% of impressions were deemed to be 'satisfactory' overall and 21% were deemed 'unsatisfactory'. These impressions, having arrived in the production laboratory, would have already been accepted as being satisfactory by staff on clinic. Thus, in addition to the quality of the impression themselves needing improvement, the quality assurance process in the clinic needed to be more thorough to identify unsatisfactory impressions at an earlier stage, ideally whilst the patient was still present. This would allow a repeat impression to be taken at the same visit, avoiding a return visit for the patient. Deficiencies in the quality assurance process has been reported elsewhere.<sup>18</sup> The subsequent action plan (Table 5) sought not only to review the undergraduate teaching, but to focus on the quality assurance process. Illuminated magnifiers were provided for use on clinic and staff were asked to check all impressions with these magnifiers or loupes. Posters were also produced for clinic that contained clinical photographs illustrating the desirable features of a good impression. These posters were attached to the clinic wall above the illuminated magnifiers and impression disinfection baths.

The results of the 2016 audit were equally disappointing. There was still 100% compliance with the disinfection procedure, but the proportion of overall 'satisfactory' impressions had dropped to 36%, and there were now issues with 18% of trays used. Out of these 18 impressions, none were found to be satisfactory, 50% had minimal defects while the other 50% (n=9) were unsatisfactory. The strong correlation between choosing the wrong tray size and an unsatisfactory impression is undeniable and is supported by BSRD guidelines, stating that trays used for impressions should "have sufficient extension to support an impression of all structures to be recorded".<sup>2</sup> Where it is difficult to select a well-fitting stock tray, consideration should be given to the use of a custom tray<sup>20</sup> although the use of custom impression trays will incur increased laboratory costs and increased clinical time for both patient and student.

The types of common defects found within the impressions were also found to have varied. In 2014, the most common defect was not having the entire margin of the prepared tooth/teeth present (42%), followed by the presence of drags and voids (30%). In 2016 the number of impressions with drags and voids present increased to become the most common defect (34%). There was also a significant increase in defects of adjacent teeth that may affect the contour and contact of the cast restoration (21%), and defects that affect articulation of casts (19%). The only defect to have seen a decrease was that of not having the entire margin of the prepared tooth/teeth present (14%). The reason for this is unknown although we

speculate that following the 2014 audit, clinicians are more acutely looking out for an accurate impression of the prepared tooth/teeth, focusing on margins of the preparation, and perhaps missing out on other defects in an impression or in the opposing impression. Regardless of explanation, it was clear that improvement was still needed.

The 2016 action plan, as well as disseminating audit results to staff and students and stressing the need for improvement, focussed on the use of illuminated magnifiers or loupes. Firstly, it was now considered mandatory to use illuminated magnifiers or loupes and secondly, the laboratory work sheet was redesigned to include a section in which staff placed their signature to confirm that one of these methods had been used. Staff were reminded, via e-mail, of the benefits of liaising with technical staff where there were areas of uncertainty.

The 2018 audit provided excellent results. The portion of 'satisfactory' impressions increased considerably to 72%, whilst the number of 'unsatisfactory' impressions fell to just 15%. A further improvement found that the correct size of tray had been selected in 100% of cases. These results were extremely encouraging and were almost at the audit target. The redesigned the laboratory form which ensured that a member of staff signed to say that the impression had been inspected under illuminated magnification was instrumental in these improved results. Furthermore, technical staff had commented that there was now much greater engagement between students, clinicians and technicians. This has the benefits of firstly, technicians being able to reject an impression, if warranted, whilst the patient was still on clinic and secondly, allowing the technician to explain to the student or clinician the reason for rejection and further their knowledge and understanding. As 2% of impressions in 2018 showed signs of incomplete decontamination, and with the need of 100% compliance, a reminder of the standard decontamination process and its importance was reinforced to all staff and students.

Whilst there is still room for improvement, if the proportion of 'satisfactory' and 'minimal defect' impressions are combined, the cycle of three audits and implemented action plans have ensured that 85% of sampled impressions were acceptable, which compares extremely favourably with previous studies.<sup>4,5,6,7,8,12,13,18</sup>

This audit has limitations. Each sample of 100 impressions was assessed by different examiners which decreases the standardisation and reliability of results across the three audits. However, the examiners undertook initial calibration exercises at the start of data

collection stage for each of the audits. In addition, the advice of a senior technician was sought for cases where there was any degree of uncertainty.

The time intervals between the three audits would have ideally been shorter which would have allowed evaluation of the effectiveness of the action plans at an earlier stage. However, this was not possible with constraints around the undergraduate curriculum.

The audit also only looked at the quality of impressions and did not investigate the outcome relating to the fit of the resulting restorations. However, this was not the remit of this audit and will form the basis of future research. The results of this audit are also not generalizable to other institutions. Each dental school will have differing teaching methods, clinical techniques and quality assurance protocols.

This paper describes a three-cycle audit, the results obtained, and the action plans implemented at one UK dental school in order to improve the quality of undergraduate crown and bridge impressions. It is thought that the introduction of illuminated magnifiers, ensuring clinicians sign the laboratory form, and greater engagement with technical staff have been the main factors which have resulted in this improvement. This paper reinforces the benefits that clinical audits can bring to all stakeholders including clinicians, patients and funding bodies. The authors hope that this paper will prove useful to other dental schools both within the UK and internationally and will provide a contemporary benchmark from which further research could be undertaken.

## **CONCLUSION**

This audit investigated the quality of undergraduate crown and bridge impressions at three time points. Over the audit period, the overall proportion of satisfactory working impressions and those with only minimal defects increased to 85% which is very encouraging and compares very favourably to many previous studies.<sup>4,5,6,7,8,12,13,18</sup> This paper reinforces the benefits of clinical audit and provides a contemporary benchmark from which further studies can be undertaken.

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**Table 1: The standards set for the purpose of the audits**

Criteria	Target (%)	Exceptions
<b>Trays:</b> both special and stock trays should: Have sufficient extension to support an impression of all structures to be recorded Be rigid in use Incorporate occlusal stops and where indicated features appropriate to aid the retention of impressions. Robust handle, preferably integral.	100	None
<b>Disinfection:</b> Completed impressions should be: Washed thoroughly Inspected using a magnification aid Subjected to an effective decontamination procedure Identified Protected and stored ready for transit to the laboratory in a way that will preclude damage, distortion or contamination. Available for the opposing arch	100	None
<b>The quality of undergraduate</b> impressions should be categorised as follows: <b>Satisfactory:</b> the required restoration can be made <b>Minimal defects:</b> adjustments by the technician will allow the restoration to be made <b>Unsatisfactory:</b> the restoration cannot be made, and the impression will need to be retaken.	90 10 0	None



**Table 2: The data collection sheet**

<b>Case Number</b>	
<b>Student Clinical Year</b>	
<b>Type of Restoration</b>	
<b>Crown</b>	
<b>Conventional bridge</b>	
<b>Adhesive bridge</b>	
<b>Inlay</b>	
<b>Onlay</b>	
<b>Evidence of:</b>	
<b>Disinfection</b>	
<b>Blood or other debris</b>	
<b>Occlusal record</b>	
<b>Opposing arch impression</b>	
<b>Laboratory prescription</b>	
<b>Type of tray:</b>	
<b>Metal</b>	
<b>Plastic disposable</b>	
<b>Special</b>	
<b>Adequate fixation used</b>	
<b>Correct size of tray</b>	
<b>Type of impression :</b>	
<b>Polyether</b>	
<b>Monophase silicone</b>	
<b>Putty &amp; Wash silicone</b>	
<b>Technique employed:</b>	
<b>One stage</b>	
<b>Two stage</b>	
<b>Full arch</b>	
<b>Sectional impression</b>	
<b>Under magnification, inspect for the presence of:</b>	
<b>Entire margin of prepared tooth/teeth</b>	
<b>Drags/voids</b>	
<b>Air blows</b>	
<b>Defects in adjacent teeth</b>	
<b>Defects affective articulation</b>	
<b>Unset impression material</b>	

**Table 3: The features associated with each working impression that would lead to the overall grading of quality.**

Quality	Reason for Classification	Associated Features
<b>Satisfactory</b>	Impression clearly records tooth preparation and <b>restoration can be made</b>	<ul style="list-style-type: none"> <li>Defined and continuous margins with no imperfections</li> <li>Absence of drags, voids or air blows</li> <li>No defects in adjacent teeth, or defects that would affect articulation</li> <li>No unset impression material</li> </ul>
<b>Minimal defects</b>	Minor faults that <b>may be adjusted by a technician</b> such that the <b>restoration can be made</b>	<ul style="list-style-type: none"> <li>Small inclusions at the margins</li> <li>Small losses of marginal integrity</li> <li>Minor imperfections in the rest of the prepared tooth/teeth</li> </ul>
<b>Unsatisfactory</b>	Significant guesswork by the technician required such that the <b>restoration cannot be made</b>	<ul style="list-style-type: none"> <li>Complete loss of marginal definition</li> <li>Extensive drags/voids/air blows</li> <li>Defects in adjacent teeth which would affect establishing contour and/ contacts of restoration</li> <li>Major defects that would affect articulation to correct occlusion</li> </ul>

**Table 4: A summary of results for the 2014, 2016 and 2018 audits**

Criteria	Target (%)	2014	2016	2018
<b>Trays:</b> both special and stock trays should: <ul style="list-style-type: none"> <li>Have sufficient extension to support an impression of all structures to be recorded</li> <li>Be rigid in use</li> <li>Incorporate occlusal stops and where indicated features appropriate to the retention of impressions</li> <li>Robust handle, preferably integral.</li> </ul>	100	100	82	100
<b>Disinfection:</b> Completed impressions should be: <ul style="list-style-type: none"> <li>Washed thoroughly</li> <li>Inspected using a magnification aid</li> <li>Subjected to an effective decontamination procedure</li> <li>Identified</li> <li>Protected and stored ready for transit to the laboratory in a way that will preclude damage, distortion or contamination.</li> <li>Available for the opposing arch</li> </ul>	100	100	100	98
<b>The quality of undergraduate</b> impressions should be categorised as follows: <ul style="list-style-type: none"> <li><b>Satisfactory:</b> the required restoration can be made</li> <li><b>Minimal defects:</b> adjustments by the technician will allow the restoration to be made</li> <li><b>Unsatisfactory:</b> the restoration cannot be made, and the impression will need to be retaken.</li> </ul>	90 10 0	42 37 21	36 42 22	72 13 15

**Figure 1a:** An example of an impression that demonstrates good soft tissue management and thus has clearly defined margins and absence of drags, voids and air blows.

**Figure 1b:** An example of an impression that would be deemed to possess minimal defects, although could be adjusted by a technician to make the restoration. In this case, there is a void present mesially which would need adjustment before the die is cast.

**Figure 1c:** An example of an impression classified as unsatisfactory. The buccal margin is indistinct, possibly due to the impression being withdrawn prematurely.

**Figure 2:** A comparison of the type of impression defects found over the audit period.

**Figure 3:** A comparison of the overall standard of impressions over the audit period.